

RARE-EARTH MINERALS IN MARTIAN METEORITE NWA 7034/7533: EVIDENCE FOR FLUID-ROCK INTERACTION IN THE MARTIAN CRUST.

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Introduction: Monazite, chevkinite-perrierite and xenotime are common rare-earth minerals in terrestrial rocks and important repositories for the rare-earth-elements (REE). Liu and Ma [1-2] reported finding monazite, chevkinite-perrierite and xenotime in NWA 7034/7533, the 'Black Beauty' meteorite. Here, we provide a more detailed textural and compositional analysis of these minerals; our results suggest an origin via fluid-rock interaction.

Results: Anhedronal monazite-(Ce, Nd) [(Ce, Nd, La, Ce, Y)PO₄] occurs with anhedronal chevkinite-perrierite-(Nd) [(Nd,Ce,Sm,Pr,La,Y,Ca)₄Fe₂(Ti,Al)₃Si₄O₂₂] in a lithic clast, and as inclusions in isolated chlorapatite grains. Cathodoluminescence imaging of monazite-bearing chlorapatite shows irregular, patchy zones that are atypical of igneous zoning. One of the chlorapatite grains contains an irregular merrillite core with monazite inclusions restricted to the mantling chlorapatite. X-ray mapping of this apatite grain further shows monazites are associated with F-regions that are cross-cut by Fe-bearing veins. Xenotime (YPO₄) occurs in a clast dominated by significantly altered pyrite, ilmenite, and altered zircon. One subhedral xenotime grain is intergrown with an altered zircon, and several euhedral xenotime grains are located between altered pyrite grains, in close proximity to the zircon. The CI-chondrite normalized REE patterns of monazite, xenotime, and chevkinite-perrierite differ from those of terrestrial igneous rocks, but are consistent with patterns for terrestrial metamorphic rocks.

Discussion: The presence of rare-earth minerals in a Martian regolith breccia, that contains alkali feldspar, is consistent with the proposal that Martian crust is enriched. The compositions and textures of the rare-earth minerals suggest dissolution/precipitation. The alteration process implies fluids at >100 °C, with monazite and xenotime solubilities that can be greatly enhanced by F and/or Cl in the fluid [3-6]. The association of monazite with higher F in chlorapatite may signal the presence of a halogen-salt bearing fluid. Since NWA 7034/7533 contains relatively fresh basaltic clasts [7] and monazite lacks association with fractures, the rare-earth minerals were likely altered in source rocks prior to their incorporation into NWA 7304/7533. Based on an apatite age of ~1.35 Ga [8], the presence of altered zircons [9-10], and potentially different protoliths for zircon and rare-earth minerals, our results suggest wide-spread hydrothermal events in the Martian crust at 1.35 Ga or earlier, caused by either large impacts or magmatic intrusion(s).

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